Shipping Traffic Analysis and Cost Assessment for Ballast Water Exchange En Route to the United States

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United States Coast Guard, Washington, DC
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Introduction

To reduce the introduction of non-indigenous species into US waters via ships' ballast water, the Coast Guard is developing regulations that address ballast water management. One component of that effort is to estimate the cost of ballast water exchange for all vessels traveling to the US from outside the US EEZ.

Assumptions

For this analysis, we collected all commercial vessel visits for the years 1999 and 2000 from the Coast Guard's Marine Safety Management System database. We then calculated, for each vessel, the total number of visits from outside the US EEZ. We used 2002 arrival data from the Coast Guard's National Vessel Movement Center to develop a picture of transit patterns for ships making port calls to the US. We assigned the last port of call to a port zone to group the ports geographically. US ports were similarly grouped into coastal zones (East Coast, Gulf Coast, West Coast, etc.).

We identified 13 transit tracks that accounted for most of the routes that vessels transit (see following 3 pages). We grouped routes in which vessels would typically not travel more than 200 miles from any shore into one transit track—***Transit within 200 miles of any shore*** **(13)**. The probability of exchange within that track was 0, since vessels transiting this track do not have the opportunity to conduct mid-ocean ballast exchange. Additionally, by categorizing transits by track we were able to determine the probability of weather conditions in each track being conducive to conduct an exchange. Specifically, we used wave height statistics to determine the probability that weather conditions would permit exchange in the sea areas applicable to each vessel track. We assumed a lower wave height limit for bulk carriers, tank ships, gas carriers, and ROROs, while we assumed container ships and other vessels with greater subdivision conduct ballast water exchange at greater wave heights.

To determine the amount of ballast water typical for each vessel type, we used data from the National Ballastwater Information Clearinghouse. In determining the amount of ballast water involved in the exchange, three volumes of ballast tank capacity are pumped for vessels completing a flow-through exchange, while two volumes of the ballast tank capacity are pumped for sequential (empty/refill) exchange. Bulk carriers, tank ships, and gas carriers were assumed to complete flow-through exchanges. All other vessels were assumed to complete sequential exchange. In determining pumping costs, we used a cost of $\$0.013/m^3$ for pumping one cubic meter of ballast water.

We also estimated additional maintenance cost, since the ballast pumps must pump the ship's capacity in ballast water for every trip into the US EEZ when cargo operations are planned. An annual maintenance cost of 10 percent of the capital cost of one ballast pump was added for each vessel conducting exchanges.

Summary of estimated costs for ballast water exchange

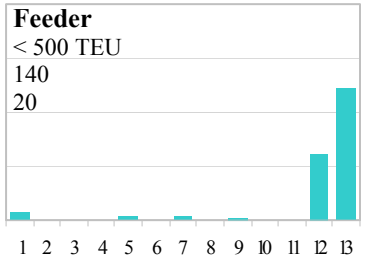
The table on the insert page presents the estimated total annual cost of exchange for 20 vessel types along with summary information for the analysis. We estimate the total annual cost of ballast water exchange for entry into US waters will be approximately $16 million. The assumptions we made regarding exchange likely overestimate annual cost. For example, we assumed that all ballast will be exchanged on every voyage to a US port from outside the US EEZ. Most operators will likely exchange only the tanks they need to before entering port, depending on the cargo operations they intend to perform once in the US. Also, we assigned a uniform annual maintenance cost to every vessel that made at least one transit outside the US EEZ; for many vessels that only make one port call in the US from outside the EEZ, this would overstate the annual cost to this vessel.

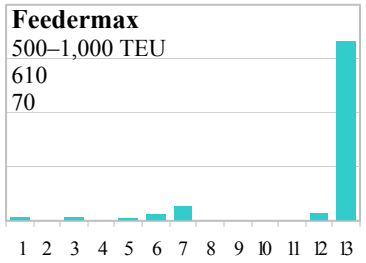
We believe that even though we could be overestimating the annual cost of ballast water exchange, our costs are indicative of the magnitude of expenditures we would expect to see.

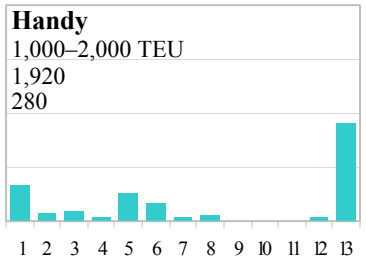
Acronyms

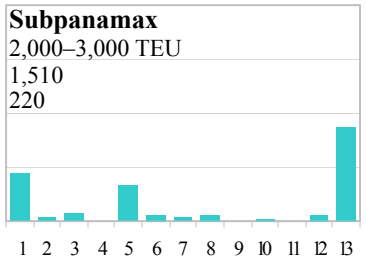
DWT	Deadweight Ton
EEZ	Exclusive Economic Zone
RORO	Roll-on, Roll-off vessel
TEU	Twenty-foot Equivalent Unit
ULCC	Ultra Large Crude Carrier
VLCC	Very Large Crude Carrier

Container ships

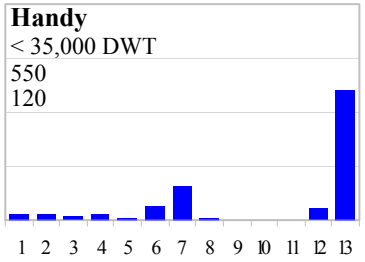


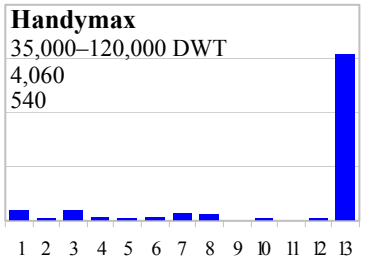


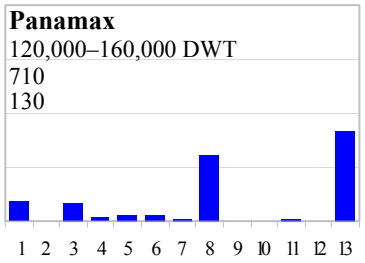


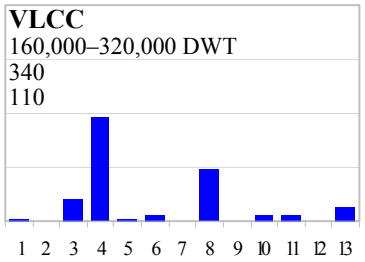


Tank ships

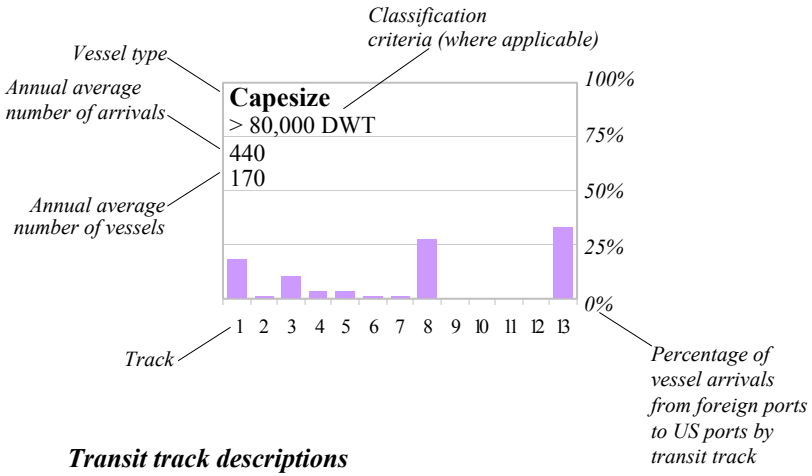








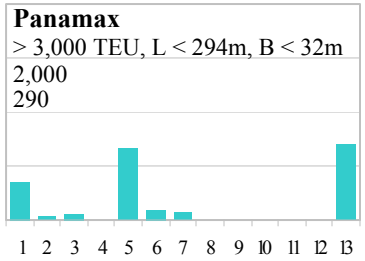
Key

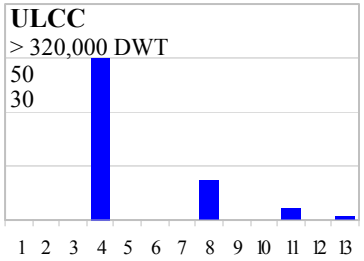


Transit track descriptions

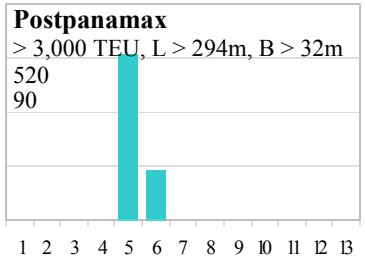
1 N. Europe to E. Coast
2 Mediterranean to E. Coast
3 N. Europe to Caribbean & Gulf of Mexico
4 Mediterranean to Caribbean & Gulf of Mexico
5 E. Asia to W. Coast
6 SE. Asia to W. Coast
7 S. America to E. Coast
8 W. Africa to E. Coast
9 C. America to Pacific Islands
10 E. Asia to Alaska
11 W. Africa to W. Coast and Hawaii
12 SE. and E. Asia to Pacific Islands
13 Transit within 200 miles of any shore

Tank ships move cargo in shipload lots and carry ballast water in the absence of cargo, rather than in addition to cargo, to optimize vessel stability and performance. The smallest tank vessels (**Handy** and **Handymax**) arrive predominantly from foreign ports with transits that lie within 200 miles of any shore (13), which shows the influence of tanker traffic from South America and the Caribbean arriving at Gulf Coast ports. These tankers carry primarily petroleum product, though smaller tankers also carry wine, molasses, edible oils, concentrates, and other liquids. Petroleum from Venezuela is seen in the concentration of **Handy** arrivals in ***S. America to E. Coast*** (7). As size increases to 160,000 DWT, and as cargo changes from product to crude oil, the distribution of arrivals across transit tracks changes. We see a shift from transits that lie within 200 miles of shore to transits from the Middle East through the Mediterranean. As shown in **VLCC**, almost 50 percent of the arrivals are ***Mediterranean to Caribbean & Gulf of Mexico*** (4). Nearly 75 percent of **ULCC** arrivals are from the Middle East through the Mediterranean.





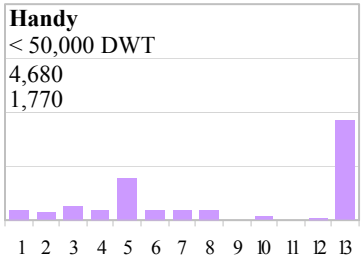
Like tankers, bulk carriers move cargo in shipload lots and carry ballast water in the absence of cargo. Bulk carriers show a similar, though less pronounced, trend than container and tank vessels. Nearly 50 percent of the arrivals for the smallest bulk carrier (**Handy**) transit from foreign ports with transits that lie within 200 miles of shore (13). For the largest carriers (**Capesize**) the number of arrivals from foreign ports that transit only within 200 miles of shore drops to just over 30 percent, followed closely by those arrivals from ***W. Africa to E. Coast*** (8). The middle group of bulk carriers (**Panamax**) those between 50,000 and 80,000 DWT, is still dominated by transits within 200 miles of shore, but there are significant arrivals in transits from ***N. Europe to Caribbean & Gulf of Mexico*** (3), ***Mediterranean to Caribbean & Gulf of Mexico*** (4), ***E. Asia to W. Coast*** (5), and ***W. Africa to E. Coast*** (8), which demonstrate the influence of both mineral and grain shipments in the bulk trades.

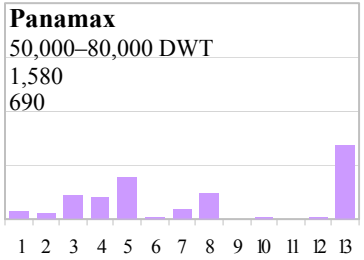


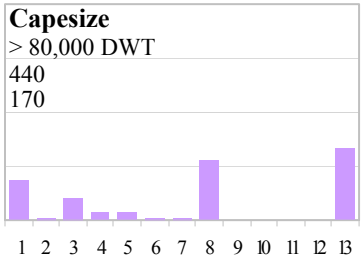
General cargo vessels, Chemical carriers, Gas carriers, ROROs, Combination vessels, and Passenger ships have arrival distributions that are remarkably similar, showing that most of these vessels arrive from foreign ports with transits that lie within 200 miles of any shore (13). In the case of **Passenger ships** and **Combination vessels**, arrivals from transits within 200 miles of shore account for nearly all arrivals. **ROROs** show over 50 percent of arrivals from transits within 200 miles of shore and also have significant arrivals from ***E. Asia to W. Coast*** and ***N. Europe to E. Coast*** (5), primarily vehicle deliveries from Asia and Europe.

Container ships carry cargo on all transits, with ballast water in sufficient quantity to optimize the stability and efficiency of the vessel. **Feeder** vessels are small container ships with a cargo capacity less than 500 TEU. We see that most of the approximately 140 arrivals by approximately 20 vessels were from foreign ports with transits that lie within 200 miles of shore (13). The track with the next highest percentage of arrivals is ***SE. & E. Asia to Pacific Islands*** (12). As shown, all of the small- and medium-sized container ships (up to 3,000 TEU) transit primarily within 200 miles of shore (13), though fewer transits in this track are shown as vessel size increases. By contrast, the largest container ships, those designated **Postpanamax**, which carry over 3,000 TEU and have dimensions that preclude transit through the Panama Canal, have arrivals concentrated in transit tracks from Asia to the West Coast (***E. Asia to W. Coast*** and ***SE. Asia to W. Coast***; 5, 6). Thus, these largest container vessels are exclusively engaged in cargo carriage in the Pacific Rim, bringing finished goods to and from the US.

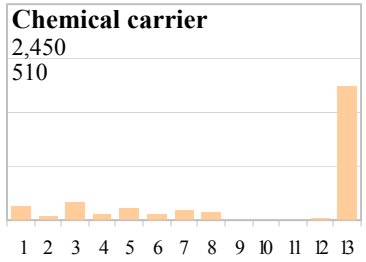
Bulk carriers

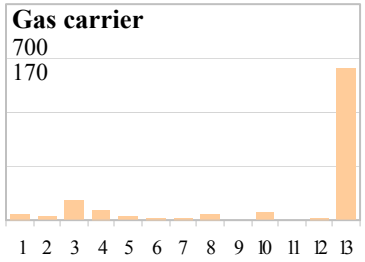


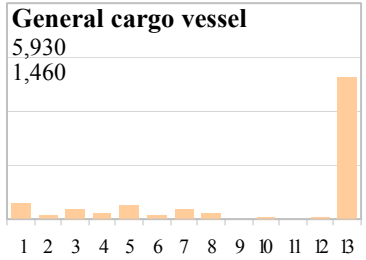


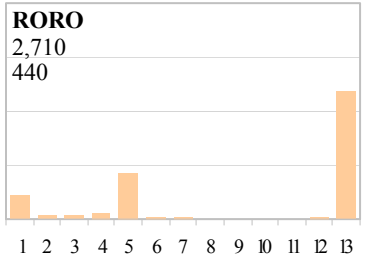


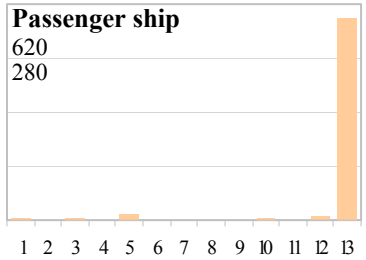
Other vessels not divided by size

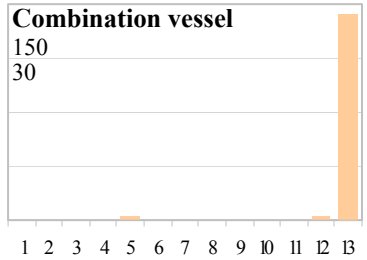






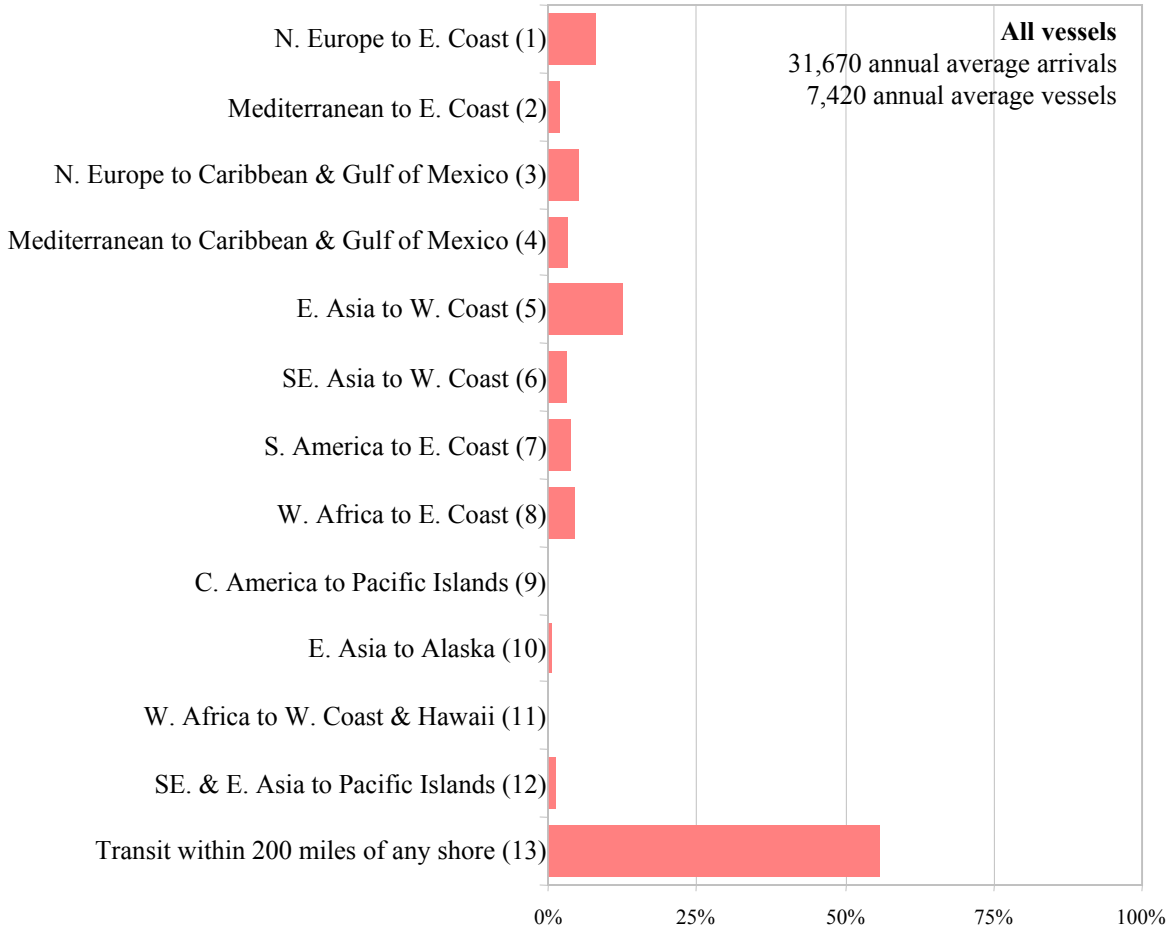






Summary of all arrivals

The distribution of all vessel arrivals across transit tracks is shown in the graph to the right. The majority of arrivals (56 percent) are from ports located such that these vessels do not travel more than 200 miles from any shore while en route to the US. The second highest percentage of arrivals is from ***E. Asia to W. Coast*** (5), with 13 percent. The next highest percentages are from ***N. Europe to E. Coast*** (1), with 8 percent, and ***N. Europe to Caribbean & Gulf of Mexico*** (3), with 5 percent.



Conclusions

The dominance of vessel arrivals where transits are within 200 miles of any shore for most vessel types highlights the difficulty in relying on ballast water exchange to have a significant effect on reducing the introduction of non-indigenous species. Vessels transiting from within 200 miles of any shore do not have the opportunity to conduct a mid-ocean ballast water exchange. As a result, the ballast water discharged from these vessels into US waters may contain non-indigenous species that could successfully be introduced and could subsequently become invasive. If these same vessels were to conduct an exchange in coastal areas, the risk of invasive species introduction remains. Any regulatory actions to mandate ballast water exchange may reduce—but will not eliminate—the transport of non-indigenous species into US waters via ballast water from ships.

Estimated annual cost of ballast water exchange for vessels en route to the US

Vessel type	Vessel description	Average vessels (a)	Prob. vessel performs exch. (b)	Average annual exch. (c)	Estimated cost per exch. (d)	Annual maint. cost per vessel conducting exch. (e)	Total ann. exch. cost ($M) (f)	Total ann. maint. cost ($M) (f)	Total ann. cost ($M) (f)
Container ships									
Feeder	< 500 TEU	20	38%	60	$75	$1,500	$0.004	$0.015	$0.019
Feedermax	500–1,000 TEU	70	17%	110	96	1,500	0.010	0.032	0.042
Handy	1,000–2,000 TEU	280	52%	1,000	208	1,500	0.207	0.313	0.520
Subpanamax	2,000–3,000 TEU	220	54%	810	361	2,000	0.290	0.306	0.596
Panamax	> 3,000 TEU, L < 294m, B < 32m	290	62%	1,250	447	2,000	0.555	0.527	1.082
Postpanamax	> 3,000 TEU, L > 294m, B > 32m	90	96%	500	497	2,000	0.247	0.161	0.408
Tank ships									
Handy	< 35,000 DWT	120	30%	170	250	2,500	0.042	0.219	0.261
Handymax	35,000–120,000 DWT	540	16%	670	1,229	3,000	0.815	1.278	2.093
Panamax	120,000–160,000 DWT	130	42%	300	2,110	3,500	0.629	0.389	1.018
VLCC	160,000–320,000 DWT	110	68%	230	3,479	5,500	0.789	0.569	1.358
ULCC	> 320,000 DWT	30	72%	40	3,627	6,000	0.118	0.140	0.258
Bulk carriers									
Handy	< 50,000 DWT	1,770	36%	1,680	690	2,500	1.159	3.482	4.641
Panamax	50,000–80,000 DWT	690	45%	710	1,388	3,000	0.981	1.767	2.748
Capesize	> 80,000 DWT	170	47%	210	2,457	3,500	0.500	0.497	0.997
Other vessels									
Gas carrier	All sizes	170	20%	150	452	3,000	0.064	0.379	0.443
Chemical carrier	All sizes	510	37%	900	278	3,000	0.249	1.192	1.441
General cargo vessel	All sizes	1,460	33%	1,930	117	2,000	0.226	1.924	2.150
RORO	All sizes	440	26%	700	200	2,500	0.140	0.831	0.971
Combination vessel	All sizes	30	4%	10	190	2,000	0.001	0.021	0.022
Passenger ship	All sizes	280	6%	40	68	1,500	0.003	0.069	0.072
Total		**7,420**		**11,470**			**$7.029**	**$8.799**	**$15.828**

(a) 1999 and 2000 data from the Coast Guard's Marine Safety Management System. Mathematical average rounded up to the nearest 10.
(b) Weighted average across transit tracks. This probability was not used in the analysis, but gives a sense of the percentage of vessels conducting exchange by vessel type.
(c) 1999 and 2000 data from the Coast Guard's Marine Safety Management System. Mathematical average rounded up to the nearest 10.
(d) Total ballast capacity (m^3) × total volumes exchanges × cost per m^3 exchanged.
(e) Ballast pump capital cost × 10 percent.
(f) Average of results from 1999 and 2000 data.